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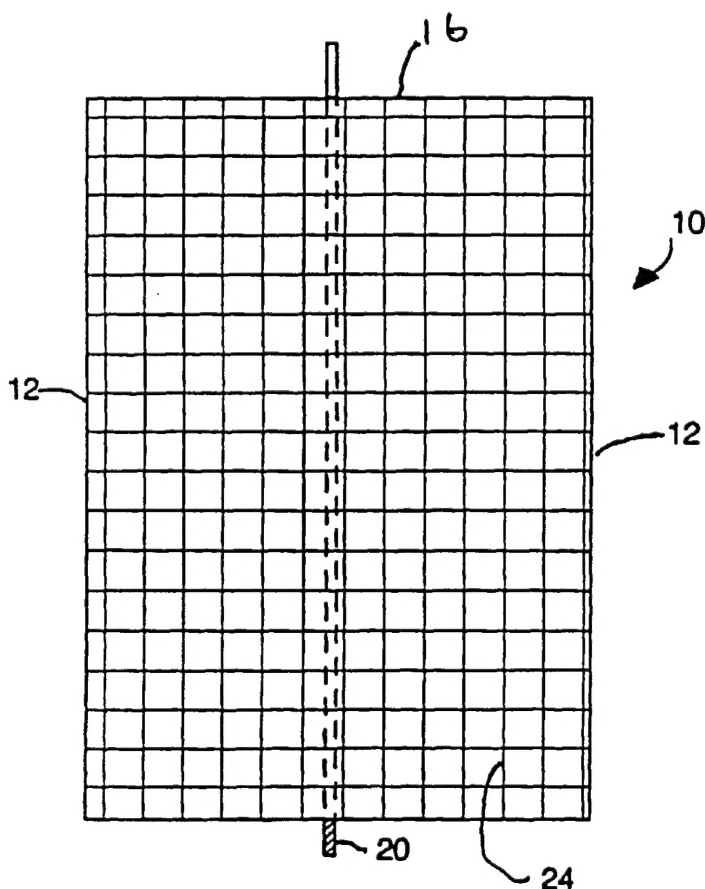
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(54) Title: **LIGHTWEIGHT CEMENTITIOUS BUILDING MATERIAL**



(57) **Abstract:** While it is known to make lightweight cementitious products using cement, water and a lightweight filler such as expanded polystyrene, perlite, vermiculite or air bubbles, their use has been limited because of poor repeatability of obtaining homogeneous mixtures. The invention provides a lightweight cementitious mixture comprising by volume: 5 to 80 % cement, 10 to 65 % expanded polystyrene particles; 10 to 90 % expanded mineral particles; and water sufficient to make a paste with a substantially even distribution of expanded polystyrene after proper mixing. The combination of expanded polystyrene particles and expanded mineral particles, such as of perlite and/or vermiculite, surprisingly enables homogeneous, repeatable mixing to occur. Thus products with stable, expected properties can be produced for a range of structural and non-structural applications.



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LIGHTWEIGHT CEMENTITIOUS BUILDING MATERIAL

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TECHNICAL FIELD:

- 10 This invention relates to lightweight cementitious mixtures and products and is concerned primarily, though not exclusively, with the use of these mixtures and/or products in the building or construction industry.

BACKGROUND ART:

- 15 Domestic and commercial buildings may be built using brick and mortar, concrete, steel, wood and combinations thereof. The selection of materials depends on preferences in any particular country or region, climate, cost of materials and labour, availability and level of skill of labour, and properties of the materials, such as strength, insulation, appearance,
20 workability, durability, and so on.

- Various lightweight cementitious mixtures are known, such as cement with expanded minerals, such as perlite or vermiculite, and aerated cement. Fibrous materials, such as wood fibres or chips may be added for strength.
- 25 It is also known to use foamed or expanded polystyrene (hereinafter "EPS") as sheets sandwiched between cementitious outer layers as panels and EPS blocks as fillers or formers when casting concrete. Attempts have also been made to use EPS in chip or particle form to make a lightweight cement mixture, but without commercial success as in practice the EPS floats on
30 the cement during mixing making it difficult consistently to achieve a homogeneous mix. It is also known that the use of lightweight cementitious mixtures with expanded minerals has been limited, because of a tendency to be porous and low tensile and compressive strength. Thus, although considerable research and effort has been expended over the years on such
35 mixtures, their use has been confined to specific applications that are generally of a short term or non-structural nature.

This invention seeks to provide a lightweight cementitious mixture or material that may be used in at least a reasonably satisfactory simple manner for domestic and commercial buildings. Optionally, the invention seeks to produce lightweight concrete products, the preparation of which is not complex and is consistent, that are satisfactorily portable, and that demonstrate sufficient structural qualities for use in construction.

DISCLOSURE OF THE INVENTION:

One aspect of the invention provides a lightweight cementitious mixture comprising cement, an expanded mineral in particle form and water, characterised in that the mixture also includes an expanded plastics material in particle form, the constituents being present in the following proportions by volume:

- 5 to 80% cement;
- 10 to 65% expanded plastics material;
- 10 to 90% expanded mineral; and
- water sufficient to make a paste with a substantially even distribution of expanded plastics material after proper mixing.

The expanded mineral may be perlite, vermiculite or mixtures thereof (hereinafter "PV"). The particles preferably range from powder to granules, e.g. about 0.05 mm to 3 mm, though larger particles may be used.

Preferably the expanded plastics material is expanded polystyrene (EPS).

This combination of ingredients mixed in this manner provides a product in which the expanded plastics material particles mix readily and evenly in the mixture. This mixing of the EPS is surprising. The mechanism of why this should occur is not yet known, but it is clear that the expanded mineral modifies one or more properties of the cement or EPS that enables it to combine with the other ingredients. A possible explanation is that it changes the conductive or electrostatic properties of the EPS. Another is that the expanded mineral bonds or adheres to the EPS. In any event the combination ensures a repeatable dispersion of the EPS in the mixed product that has not been achievable in a repeatable manner previously.

Preliminary tests prior to filing the application from which priority is claimed had indicated that the percentage by volume of cement in the

- mixture should be greater than 15%, but more testing has proven that 5% by volume of cement is sufficient for certain applications, such as for insulating, filling and decorative building components. Such testing has also refined a more preferred range in which the ingredients should be present, namely by volume:
- 10 to 55% cement
 - 10 to 45% EPS;
 - 15 to 80% PV; and
 - water.

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In use the mixture is made by first mixing the cement with water to obtain a substantially uniformly mixed slurry or paste, then adding the PV and mixing again, and finally adding the EPS and mixing again.

15 When set or cured, products made from the mixture:

- (1) can bear substantial load;
- (2) are substantially crack resistant, believed to be because of the unique inter-bonding of the EPS, PV and cement;
- (3) absorb shock, even severe shock, because of the elasticity and shock absorbing properties of the EPS beads;
- (4) has elastic properties enabling it to deform and, depending on the extent of the deformation, return to its original state;
- (5) have thermal insulation qualities;
- (6) are able to absorb and deaden or not transmit sound and noise;
- 25 (7) may be drilled, cut, sawn, planed, sanded, chiselled, nailed screwed, and/or bolted;
- (8) may be used for building to create walls, roofs, floors, foundations and columns and the like structural and non-structural elements;
- (9) are substantially water impervious making it suitable for roofing or roof covering/waterproofing, walls and the like of buildings; and
- 30 (10) can be extruded to form roofing, ceilings, decorations, and floor mouldings.

Fibre reinforcing, using metals, plastics, organic fibres, woven and non-woven netting using such fibres and combinations thereof may be used with the mixture.

Preferably, when completely mixed, the paste has the consistency of a pastry dough, care being taken to ensure that the cement is not excessively hydrated; this is in any event a known good practice for cement. However, depending on the intended use of the mixed product, additional hydration
5 may be used to make the mixture pourable for in situ building or production line casting of blocks, slabs, bricks and the like.

The perlite, vermiculite or mixtures thereof may be siliconized, ie. coated by mixing the powder with heat vaporised silicon, or coated with a vitreous
10 material such as an appropriate glass composition. This is not essential.

Preferably the cement is Portland cement.

Preferably the EPS particles have a diameter or nominal cross-section of
15 1 to 10 mm. A range of particle sizes or classified particles, ie. a selected narrow range of particle sizes, may be used as desired.

The EPS particles may be beads, ie. substantially round and smooth, though this is not an essential requirement, and may have other shapes.
20 Irregularly shaped particles can be obtained relatively inexpensively by grinding, grating, cutting, etc. waste EPS.

Another aspect of the invention provides a cast product made from the mixture of the invention described above.
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Yet another aspect of the invention provides a method of making a lightweight concrete mixture comprising cement, expanded plastics particles and water, characterised by including the steps of:-

- a. mixing the cement and water to form a slurry of a desired consistency;
- 30 b. then adding and mixing a desired quantity of a suitable expanded mineral in particle form with the slurry; and
- c. then adding and mixing the expanded plastics particles for a sufficient time to ensure the expanded plastics particles are substantially homogeneously dispersed in the mixture.

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Preferably the constituents of the mixture are present in the quantities described above.

Using the mixture and method of the invention with suitable relative proportions of the ingredients as required it is possible to produce a wide range of products, ranging from floor slabs, load-bearing walls, roof tiles, columns (both decorative and load-supporting), statuettes, hot tubs, and building elements in slab, panel, block or brick form of various sizes having strengths of the cured product ranging from 1 Mpa to 40 Mpa (Mega pascals). Thus the product can be used for structural and decorative purposes.

10 The mixing of the ingredients may be performed using a standard volume measure, such as a bucket, wheel barrow, loader bucket, loading skip or hopper, etc. and then following conventional mixing concrete methods, using hand, drum or pan mixers. Pan mixers are preferred. Thus special or different expertise is not required for performing the mixing, although
15 selection of the appropriate mix does require care and expertise for structural components.

Further features, variants and/or advantages of the invention will emerge from the following non-limiting description of examples of the invention,
20 some of which are made with reference to the accompanying schematic drawings.

BRIEF DESCRIPTION OF THE DRAWINGS:

Figure 1 shows a plan view of an example of a reinforced panel made from
25 the mixture of the invention;

Figure 2 shows a side view of the example of Figure 1; and

Figure 3 shows an end view of the example of Figure 1.

DESCRIPTION OF PREFERRED EMBODIMENTS:

30 The drawings show an elongate rectangular slab or panel 10 that may be used for walls and roofing. The slab 10 has two long edges 12, each formed with a groove 12.1, a squared off bottom edge 14, a 45° bevelled top edge 16, opposed front and back faces 18, embedded steel wire mesh 24 with 150 mm openings (other sizes may also be used if desired), and a securing rod 20
35 embedded in the slab. As seen in the end view, the mesh is supported on top hat stands 22 and the securing rod 20 is supported on and tied to the mesh. One end of the rod is threaded and the other end has a hook.

In use, the slabs are used to form wall panels and a roof, with the hook of one of the roof and wall slabs being secured by a nut and washer to the hook of an abutting wall and roof slab, respectively. Grout is provided as a bonding and sealing material between laterally adjacent slabs.

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EXAMPLES:

In each of the examples given below, a small bucket having a volume of about 2,36 litres (about one twelve of a cubic foot) was used. In each example the mix was composed of Perlite S30, Portland Cement, EPS beads of about 10 3 mm diameter and water. The mixture was made by mixing the cement and water to form a slurry, adding Perlite mixing again, and finally adding the EPS beads and then mixing again for about 5 minutes.

1. A mix of 4 buckets EPS beads, 5 buckets Portland cement, 1 bucket powdered Perlite, and 2,75 buckets water (6,5 litres) was prepared as above and cast into sample blocks. After 37 days hardening in air a compression test on the blocks yielded a strength of 1480 psi (pounds per square inch), ie. about 10 Mpa.

20 2. A mix of 5 buckets EPS beads, 4 buckets Portland cement, 4 buckets powdered Perlite, and 2,5 buckets water (about 6 litres) was prepared as above and cast into sample blocks. After 37 days hardening the strength was measured at 860 psi, ie. about 6 Mpa.

25 3. A mix of 6 buckets EPS beads, 3 buckets Portland cement, 3 buckets powdered Perlite, and 2,1 buckets water (about 5 litres) was prepared as above and cast into sample blocks. After 37 days hardening the strength was measured at 680 psi, ie. about 5 Mpa.

30 In each of examples 1 to 3 above, the material showed an indentation under pressure, the material restoring itself somewhat as the EPS beads expanded.

4. A mix of 4 buckets EPS beads, 5 buckets Portland cement, 1 bucket powdered Perlite, and 2,75 buckets water (about 6,5 litres) was prepared as above and cast into sample blocks in a 300 x 300 x 125 mm mould. A sheet of 300 x 300 mm galvanised wire mesh with 100 x 100 mm openings was positioned midway in the mould. After 32 days hardening the strength was measured at over 2000 psi, ie. over 14 Mpa.

Tests on example 4 after 32 days hardening were as follows:-

- a. A flame spread test of 2000 F° at 3 mm for 2 hours showed no deterioration affecting structural performance other than 2 miniature 12 mm lizardations extending for a depth of about 3 mm. A 4 hour test
5 showed no further change.
- b. Shrinkage after cure was less than 1 mm.
- c. Load test: higher than 2000 pounds (900 kg).
- d. Wind test: higher than 150 M.p.h. (245 kph).
- e. Drop test: a body with a one square inch impact formation, 5 pounds
10 (2.26 kg) drop from 3 foot (915 mm) height, produced an indentation of less than 3 mm.
- f. Weathering test: pass
- g. samples cut into four sections showed an even distribution of beads.

15 Where figures are given above, those in imperial measure take preference if there is a discrepancy between the imperial and metric measures.

Further samples have been made and tested with the following results:

- 20 5. A mix of 3 buckets EPS beads, 5 buckets Portland cement, 1 bucket powdered Perlite, and 2,75 litres water was prepared as above and cast into sample blocks. After 28 days hardening the strength was measured at 22 Mpa., ie. about 3000 psi.
- 25 6. A mix of 3 buckets EPS beads, 5 buckets Portland cement, 2 buckets powdered Perlite, and 2,75 litres water was prepared as above and cast into sample blocks. After 28 days hardening the strength was measured at 18 Mpa., ie. about 2600 psi.
- 30 7. A mix of 3 buckets EPS beads, 5 buckets Portland cement, 3 buckets powdered Perlite, and 2,75 litres water was prepared as above and cast into sample blocks. After 28 days hardening the strength was measured at 17 Mpa., ie. about 2500 psi.
- 35 Benefits of the invention are that the mixture is homogeneous and the properties of cast products are thus repeatable. Accordingly lightweight cementitious products with stable, expected properties can be produced for a range of structural and non-structural applications. From the results, it

appears that the EPS adds strength, and heat and sound insulating and elastic properties to the product, while the PV decreases strength but aids obtaining a homogeneous mix.

- 5 The invention is not limited to the precise details described above. Modifications may be made and other embodiments developed without departing from the scope of the invention as defined in the claims. For example, the reinforcing in the panel shown in the drawings and described above has been provided to comply with US regulations for earthquake prone zones and
- 10 to inhibit cracking - it may be omitted where appropriate.

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CLAIMS:

1. A lightweight cementitious mixture comprising cement, an expanded mineral in particle form and water, characterised in that the mixture also
5 includes an expanded plastics material in particle form, the constituents being present in the following proportions by volume:
 - 5 to 80% cement;
 - 10 to 65% expanded plastics material particles;
 - 10 to 90% expanded mineral particles; and
 - 10 -- water sufficient to make a paste with a substantially even distribution of expanded polystyrene after proper mixing.
2. The mixture of claim 1, characterised in that the mixture comprises, by volume,
15 -- 10 to 55% cement
 - 10 to 45% expanded plastics particles;
 - 15 to 80% expanded mineral particles; and
 - water.
- 20 3. The mixture of claim 1, characterised in that the expanded mineral is selected from expanded perlite, expanded vermiculite and mixtures thereof.
4. The mixture of claim 3, characterised in that the expanded mineral
25 is in powder form.
5. The mixture of claim 1, characterised in that the expanded plastics material is expanded or foamed polystyrene.
- 30 6. The mixture of claim 1, characterised in that the expanded plastics particles have a nominal cross-section of 1 to 10 mm.
7. The mixture of claim 1, characterised in that the expanded plastics particles have a nominal cross-section of about 3 mm.
- 35 8. The mixture of claim 1, characterised in that the expanded plastics particles are in the form of substantially round, smooth beads.

9. The mixture of claim 1, characterised in that it includes elongate reinforcing, the elongate reinforcing being selected from plastics and organic fibres, woven and non-woven netting using such fibres, metal wires, metal wire mesh, and combinations thereof.

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10. A method of making a lightweight concrete mixture comprising cement, expanded plastics particles and water, characterised by including the steps of:-

- a. mixing the cement and water to form a slurry of a desired consistency;
- 10 b. then adding and mixing a desired quantity of a suitable expanded mineral in particle form with the slurry; and
- c. then adding and mixing the expanded plastics particles for a sufficient time to ensure the expanded plastics particles are substantially homogeneously dispersed in the mixture.

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